The failure of practical aviators to obtain automatic stability may be due in no small measure to the number of conditions that have to be satisfied. A vertical fin in front might satisfy one condition of stability, and introduce instability through another condition, while a similar fin at the back might satisfy the second condition and introduce instability through the first. In either case the impression produced would be that the device secured automatic stability, but that such stability was a hindrance rather than a help, the correct interpretation being that the conditions of stability had not been sufficiently investigated. By abolishing the fins the aviator would obtain a machine with *defective stability, i.e.* with one or more roots of the biquadratic vanishing, and would find it easier to maintain his balance by artificial control than in the previous unstable arrangement.

Of arrangements with two fins, the cases have been considered where both fins are at the level of the centre of gravity, where one is above, and where both are above. The conditions of stability assume various forms, but there is one arrangement which appears to possess an exceptionally wide range of stability, and I have made provisional application for a patent in this connection.

A machine such as the Voisin type, with two planes of considerable span at different angles of attack, is more stable than one with a single sustaining system, and the difference is equivalent to a variation in the arrangement of the fins which is easily calculated.

The asymmetric oscillations of an aërodrome do not separate into two kinds, of long and short period, like the symmetric ones. As a general rule the biquadratic has one root determined approximately by the first two terms representing a quick subsidence, one root determined by the last two representing a slow subsidence, and a pair of roots determined by the middle terms representing a damped oscillation.

The inclination of the flight-path to the horizon has a considerable influence on the asymmetric stability. In several instances we found that instability occurs when an aërodrome is descending at an angle to the horizon the tangent of which is double that of the angle of attack of the main planes. Other arrangements become unstable when rising at more than a certain angle; in the best arrangement referred to above the stability is practically independent of the inclination. As the symmetric and asymmetric oscillations of an aëroplane are independent, it is important that it should preserve its asymmetric stability even when it is not in longitudinal equilibrium. The dependence of stability on inclination affords a very simple and likely explanation of certain "vagaries" described on pp. 342, 343 of Lanchester's "Aërodonetics"; account would, however, have to be taken of accelerations of the centre of mass in an exact comparison of theory with observation.

Bent-up or V-shaped wings lead to much more difficult analysis, and it appears that their effect is not exactly equivalent to any combination of vertical fins except in certain cases. A pair of "stabilisers" or small planes, which may be fixed at the extremities of the main aëroplanes at an angle of, say 45°, is equivalent to a single raised vertical fin if the planes of the stabilisers are parallel to the line of flight.

Mr. Harper has worked out the asymmetric stability of the Antoinette type with a single pair of bent-up supporting surfaces. The conditions of stability are satisfiable by furnishing the machine with a tail of suitable length, or by raising the dihedral angle of the V-shaped wings above the centre of gravity.

I should like to direct attention to the importance of eliminating the personal element in experimental tests of aëroplane stability, by the use of models. The possibility of long-distance flights by skilled aviators having been demonstrated, there is not so much point in repeating these verifications as in extending our knowledge in other directions, and finding how far the element of skill can be dispensed with by effecting improvements in aëroplane design.

The stability of dirigibles opens up another field of study, on which we hope to do something during the coming year.

Owing to the attention now given to aëroplane construction, it appeared desirable to give, in the present article, an advance account of investigations which may not be ready for publication *in extenso* for some time to come. G. H. BRYAN.

Added January 27, 1910.—The *Aëronautical Journal* for January, now to hand, includes a short abstract, illustrated by badly executed diagrams, and containing numerous uncorrected printers' errors, in which the symmetric stability of a single-surfaced aërodrome without tail is made to depend on a cubic instead of a biquadratic equation. This result is obtained by the very doubtful method of "assuming V to be constant for a short period," that is, neglecting fluctuations in horizontal velocity. Owing to this assumption the conclusions reached may perhaps represent the conditions that the machine may be stable with reference to the shorter oscillations, but not with respect to the longer ones, and the inference that a machine can be much more stable at moderate velocities than is generally supposed must not be regarded as conclusive.

THE WORK OF THE WOBURN FRUIT FARM.[1]

AMONG the profusion of agricultural and horticultural reports, many of which can at best be said only to possess a very ephemeral interest, it is pleasant to come across something of permanent and abiding value, work carefully executed and followed to its logical conclusion.

Such must be the feeling of every discerning reader as he studies the report by the Duke of Bedford and Mr. Spencer Pickering on the chemical relationships of the copper fungicides. The problem is one of very great economic importance. Modern conditions of fruit-growing tend to foster and distribute from country to country the fungi parasitic on fruit trees. On the other hand, the grower is more and more anxious to keep them down; not only do they adversely affect his yield, but they often spoil the looks of his fruit, a very serious matter in modern markets.

The most popular fungicides are the copper compounds, more particularly Bordeaux mixture, a basic salt prepared by adding lime to a solution of copper sulphate. This mixture has been used by fruit and potato growers for a number of years with great success, and has formed the subject of a vast number of papers. Unfortunately few of them are of much value, since it only rarely happens that a man is found to combine an interest in horticultural problems with exact habits of thought. Until recently nothing was known of the composition of Bordeaux mixture, not even the proportions in which the constituents should be mixed to give the best results. Certain American investigators recommended 4 lb. of copper sulphate in fifty gallons of water, and some of the English writers, borrowing not too intelligently in this as in other matters, recommended the same strength, oblivious of the fact that the American gallon is little more than four-fifths of the English

[1] Eleventh Report of the Woburn Experimental Fruit Farm, by the Duke of Bedford, K.G., F.R.S., and Spencer U. Pickering, F.R.S. (The Amalgamated Press, Ltd., 1910.)

gallon. There are several other recipes, but nothing enabling one to decide which is the best. The mode of action is even more obscure; indeed, the whole subject was in a state of confusion until Mr. Pickering took it in hand and began to evolve something like order.

The reaction between copper sulphate and lime is shown to yield four basic sulphates:—(*a*) $4CuO,SO_3$; (*b*) $5CuO,SO_3$; (*c*) $10CuO,SO_3$; (*d*) $10CuO,SO_3,CaO$; and two other compounds (*e*) $CuO,2CaO$ (existence doubtful); (*f*) $CuO,3CaO$. The conditions of the formation of each of these basic sulphates were investigated and a series of the corresponding Bordeaux mixtures prepared.

The properties of the sulphates were studied, and in particular their decomposition under the influence of water and carbonic acid in presence of calcium sulphate or of organic matter, these being the conditions obtaining on the leaf surface. The next problem was to ascertain the function of Bordeaux mixture and so to settle which was the most useful of the possible basic sulphates. These salts are, of course, insoluble and have to be converted into a soluble substance before they can exert a fungicidal action. No evidence could be obtained that the plant leaf or the spore excreted anything that would dissolve an insoluble substance, but it was shown that the carbonic acid of the air decomposed these basic sulphates in accordance with the following reactions:—

(*a*) $10CuO,2{\cdot}5SO_3+3{\cdot}75CO_2=3{\cdot}75(CuO)_2,CO_2+2{\cdot}5CuSO_4$.
(*b*) $10CuO,2SO_3+4CO_2=4(CuO)_2,CO_2+2CuSO_4$.
(*c*) $10CuO,SO_3+4{\cdot}5CaO=4{\cdot}5(CuO)_2,CO_2+CuSO_4$.
(*d*) $10CuO,SO_3,3CaO+7{\cdot}5CO_2=4{\cdot}5(CuO)_2,CO_2+3CaCO_3+CuSO_4$.

The copper sulphate thus liberated constitutes the active part of the mixture. It acts in two ways. It directly poisons the fungus cell developing from the spore. Some of it gets into the leaf, displacing a certain amount of iron and entering into a remarkable combination not yet investigated, which seems so long as it persists to afford the leaf immunity against fungal attacks. Further studies of this remarkable body will be awaited with interest; it will be remembered that Church isolated a pigment *turacin* containing copper from certain genera of the family Musophagidæ, but no such pigment is known in the vegetable kingdom up to the present. But to return: the object of the fungicide is to furnish a steady supply of copper sulphate, and therefore the compound (*a*) is the most efficient of the series. In the case of (*d*), the ordinary Bordeaux mixture, a secondary reaction sets in between the calcium carbonate and the copper sulphate which further reduces its efficiency. (*a*) is, however, physically less suitable than (*c*). The whole leaf surface of the tree has to be covered with the mixture, and consequently the more bulky the mixture the better; since (*c*) occupies more than four times the volume of (*a*) it makes the most economical fungicide in practice. From the fruit-grower's point of view this compound has the further advantage that it can be made on the commercial scale and sent out as a paste ready for use. The paste has been extensively tried in orchards, with results that have completely confirmed the laboratory experiments. Several interesting side-issues were followed up. Some of the compounds in the ordinary Bordeaux mixture and in the so-called soda Bordeaux, obtained by mixing copper sulphate and sodium carbonate, contain copper in the electronegative condition, *i.e.* in the acid radical, and were called cupricarbonates; they appear to have no fungicidal action, they combine with cellulose, and slowly decompose to form cuprous oxide.

The report will be found one of the most interesting that has issued from Woburn. E. J. R.

UNDERGROUND TOPOGRAPHY IN IRELAND.

THE exploration of caves has become an athletic pursuit for certain enthusiastic specialists, perhaps as a complement to mountain-climbing. The results, however, have distinct scientific value, when careful plans of the caves are made, and underground waterways are traced. Attention has been directed in these pages to the economic bearing of "spelæology" in the Juras, and the work of the geographer is obviously incomplete, if his streams terminate, as so often happens, in swallow-holes in a limestone area, while others appear freshly on the surface, but may prove to be old friends returning to the upper world. Cave-research is arduous and often dangerous, and the wonder is that such accurate observations are provided for us by men who have to work under cramped conditions, and sometimes liberally immersed in water.

The Royal Irish Academy (Proceedings, vol. xxvii., section B, 1909) has recently issued two geographical memoirs on Irish caves. The first (pp. 183–192, price 6*d*.) is by Mr. Harold Brodrick, on "The Marble Arch Caves, County Fermanagh: Main Stream Series." The principal cave was explored and described by M. Martel some twelve years ago, with the assistance of the Irish naturalist, Dr. H. Lyster Jameson. Mr. Brodrick, with Dr. C. A. Hill, Mr. R. Lloyd Praeger, of Dublin, and other workers, was able to devote a longer time to the exploration of the district. The training and experience gained by most of the party in Yorkshire enabled them to add many new points to the topography of the area. As Mr. Brodrick remarks, the Marble Arch cave will "probably never become a show-cave, as the climb from the foot of the Great Boulder Chamber to the end of the Pool Chamber Passage is not one to be rashly undertaken." The by-paths of the recent exploration led the adventurers into several difficult places, not to speak of waters, where few will care to follow them. A large-scale map is provided, on which, however, the names used in the text are not always to be found.

The second paper (pp. 235–68, with four plates, price 1*s*. 6*d*.), on "The Mitchelstown Caves, County Tipperary," has a wider general interest. The authors are Messrs. C. A. Hill, H. Brodrick, and A. Rule; but Mr. R. Lloyd Praeger took part in the exploration. The New Cave, between Mitchelstown and Cahir, is probably the best-known cave in Ireland; but the plan now given of it seems to be far more accurate than that published by M. Martel, and includes several passages and chambers previously unrecorded. The work may not have been so exciting as that among the unfathomed waterways of Fermanagh, but one and a half miles of cave and passage have been mapped out. A curious point is that the names "Demon Cave" and "Victoria Cave" were found chalked up in some of the unrecorded portions, and these have been adopted in the plan. The names in this plan, by the bye, require one or two corrections to bring them into agreement with the text. The account of the New Cave might have been rendered even more complete by a reference to Prof. Carpenter's paper on its fauna in the *Irish Naturalist* for 1895.

Still more interesting is the description of the smaller Old Cave, which had apparently not been visited by tourists since 1833. The plan now given, covering 479 yards of cave and passage, is the first that has been made.

The clay of the cave-floors, which, as all visitors know, renders them unpleasantly slippery, is described on p. 267 as derived by inwashing from the Old Red Sandstone; but the quartz crystals noted in it, which are so common in the Carboniferous Limestone, and its general character as a *terra rossa*, make it